

**Mass Release and Recovery of *Cybocephalus nipponicus* (Coleoptera:
Cybocephalidae) on Elongate Hemlock Scale, *Fiorinia externa*.**

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Introduction

The elongate hemlock scale (*Fiorinia externa* Ferris) is a serious pest of eastern hemlock, *Tsuga Canadensis* (L.) Carriere and was first discovered in New York City in 1908 (Sasscer 1912). It is found from Massachusetts to Virginia and west to Ohio (Kosztarab 1996). It can kill hemlock trees over time and works synergistically with the hemlock woolly adelgid (HWA) to accelerate the decline of hemlock (McClure 2002). It has also been found to kill hemlocks after a heavy HWA infestation has passed through an area and then declined leaving trees with high *Fiorina* scale populations (Danoff-Burg and Bird 2002). The elongate hemlock scale (EHS) has one generation per year in the northeastern United States (McClure 1978) and there are few North American biological control agents that are effective. In McClure (1986) *Aspidiophagus citrinus* Craw (Hymenoptera: Aphelinidae) and *Chilocorus kuwanae* Sylvestri (Coleoptera: Coccinellidae) were shown to be effective biological control agents in Japan and are present in the United States but with only one generation per year in the US versus the two generations of EHS in Japan, the parasites are not as effective. Also, in Japan there is a high degree of synchrony of *A. citrinus* with the host because *A. citrinus* requires two generations per year to complete its life cycle and that allows it to build up to effective levels. In the United States, *A. citrinus* completes two generations per year, but since EHS has only one generation per year its life cycle is asynchronous with *F. externa* which reduces its effectiveness (McClure 1986, 2002). In New Jersey, the coccinellid, *Chilocorus stigma* (Say) fills the same ecological niche as *C. kuwanae* but it is not as effective in suppressing the scale populations in most instances. *C. kuwanae* has been released and established in New Jersey but has never been recovered on hemlock by Phillip Alampi Beneficial Insect Laboratory staff. All *Chilocorus* species found on hemlock have been *C. stigma*. In New Jersey approximately 90% of the hemlock stands have been seriously impacted by the HWA and most of them also have an EHS infestation (Mayer et. al. 2002).

Since 1986, the Phillip Alampi Beneficial Insect Laboratory (PABIL) has been working with a predatory beetle, *Cybocephalus nipponicus* Enrody-Younga, (Coleoptera: Cybocephalidae) (Figure 1), a tiny exotic predatory beetle from China/Korea which has been effectively used as a biological control agent on the euonymus scale, *Unaspis euonymi* (Comstock) (Homoptera: Diaspididae). *C. nipponicus* is a predator on armored scales in the family Diaspididae and also feeds on San Jose scale, *Diaspidiotus perniciosus* (Comstock) and juniper scale *Carulaspis juniperi* (Bouche). The beetles were initially shipped to the Phillip Alampi Beneficial Insect Laboratory from the USDA/APHIS/PPQ Laboratory in Niles, Michigan and were released on scale-infested euonymus plants. In 1994, the PABIL initiated a mass-rearing program in New Jersey that allowed the lab to substantially increase the numbers of *C. nipponicus* released and the number of release sites. All of the PABIL's rearing stock originated from Chinese collections while the beetles that were shipped to the PABIL for direct field release were of Korean origin.

In 1999, two interesting events occurred that heightened the laboratory's interest in *C. nipponicus* as a possible predator of the EHS. In 1999, *C. nipponicus* was recovered from hemlock sites at Washington Crossing State Park and at the Freer

Nature Preserve in Colts Neck, New Jersey while surveying for the introduced predator of the hemlock woolly adelgid, *Sasajiscymnus tsugae*. The beetles were not released in those stands but were released on euonymus scale at 3 sites nearby the Freer Preserve in Monmouth County in 1996/1997 and in 1995 at one site near Washington Crossing SP. All of the release sites were within one mile of the hemlock stands. The recovery was originally thought to be a coincidence but the collection of the beetles on EHS in succeeding years at the Freer Preserve in Monmouth County and at other sites gave us an indication that the beetle may be dispersing onto and feeding on the EHS (Table 1).

The second event was an inundative release of 300-400 *C. nipponicus* on the young scale-infested hemlock trees in the exterior hoop/shade-house/cold frame at the laboratory. The beetles rapidly reduced the *EHS* population and gave a strong indication that the beetles would feed on the EHS.

The genus *Cybocephalus* has recently been revised in North America by Smith and Cave (2006) resulting in the placement of the genus in its own family, the Cybocephalidae. *Cybocephalus* used to be in the Nitidulidae but there are sufficient morphological and behavioral differences to warrant the change in families. *Cybocephalus nipponicus* is now the official taxonomic name of the species and it is no longer *Cybocephalus sp. nr. nipponicus*.



Figure 1. *Cybocephalus nipponicus* male, female and larva

Materials and Methods

In 2000, releases were made at Allamuchy Mt. State Park in Warren County, the Upper Wickecheoke Reserve in Hunterdon County and the Princeton Battlefield State Park in Mercer County in an attempt to establish the beetles (Table 2). The beetles were packed in Fonda® 8 oz. containers with excelsior, 500 beetles per container (Figure 2). At the release site the lid was removed and the containers and lids were placed into the branches of the tree. After five minutes, any remaining beetles in the containers were gently brushed out onto the infested branches using a soft, 1-inch camel hair paintbrush. Collections of *C. nipponicus* were made during a ten minute walk at each site or by beating branches with a whiffle ball bat below which was placed a one meter square beating sheet (Figure 3). Any *C. nipponicus* recovered in the years after release were collected and brought up to the Phillip Alampi Beneficial Insect Laboratory to confirm identification.

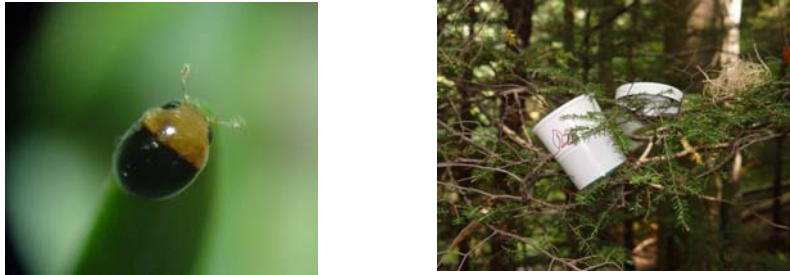


Figure 2. *C. nipponicus* dorsal view of male and release container



Figure 3. Sampling for *C. nipponicus*

From 2001 to 2004, 85,500 *C. nipponicus* were released into sites in the Newark Watershed (30,000), High Point State Park (50,000) and the Wickecheoke Preserve (5,500) in Hunterdon County. Release sites were found to have statistically significant fewer scales than the controls (Mayer et. al. 2005). Releases continued in 2005 and 2006 at various sites.

Results and Discussion

Table 1 shows the recoveries of *C. nipponicus* at sites where field personnel surveyed for *Sasajiscymnus tsugae* from 1999 through 2006. Six of the sites, Washington Crossing, Johnson Lake, Freer Nature Preserve, Lake Valhalla Dunnfield Creek and Hackettstown never received any releases of *C. nipponicus* although the beetles were released nearby on euonymus plants infested with the euonymus scale *U. euonymi* and dispersed to the hemlock.

Table 1. Recoveries of *C. nipponicus* at *Sasajiscymnus tsugae* Release Sites

SITE*	YEAR(S) of RECOVERY		
Washington Crossing State Park	1999,	2002,	2004, 2005, 2006
Freer Nature Preserve	1999, 2000, 2001, 2002,		2004, 2005
Lake Valhalla		2002, 2003	2006
Princeton Battlefield State Park		2002, 2003, 2004, 2005, 2006	
Johnson Lake		2002, 2003	
Allamuchy State Park		2002, 2003, 2004	2006
Cedar Pond, Newark Watershed			2004
High Point SP, Minisink Valley Section			2004
Clinton Reservoir, Newark Watershed			2004
Westcott Preserve			2005
Stokes State Forest, stand 16.2			2005
Wawayanda State Park			2005
Dunnfield Creek, Worthington State Forest			2005
Hackettstown Alumni Field			2005
Milford			2006
Swartswood SP			2006
Stoney Lake			2006
Worthington SF			2006
Kittatinny Valley SP			2006
Deepcut County Park			2006
Sparta Mountain WMA			2006
Stanton Station County Park			2006
Pine Hill County Park			2006
Lake Ocquittunk			2006
*sites noted in red are release sites			

C. nipponicus has been established throughout New Jersey on euonymus by the Phillip Alampi Beneficial Insect Laboratory and it has been observed feeding on juniper scale, *Carulaspis juniperi* Boche, pine needle scale, *Chionaspis pinifoliae* (Fitch) and San Jose scale, *Quadraspidiotus perniciosus* (Comstock). Smith and Cave (2006) list 14 species of armored scales that are fed upon by *C. nipponicus*.

The PABIL rears *C. nipponicus* on San Jose scale infested butternut squash and has released a total of 996,580 beetles in New Jersey since 1986. The beetle is found on almost every scale infested euonymus plant that is checked and is distributed throughout New Jersey (Matadha et. al. 2003). Van Driesche et. al. (1998) observed that *C. nipponicus* dispersed from the original release sites in New England.

C. nipponicus has considerably reduced euonymus scale, *U. euonymi* populations in landscapes in New Jersey reducing damage to the plants (Mayer et. al. 1995, Hudson et. al. 2001). The beetles tend to remain on the plants until the food source is exhausted, then disperse and return when the scale population has increased.

Since 1999 *C. nipponicus* has been increasingly found on hemlock, although in low numbers. Table 1 shows the sites where recoveries of *C. nipponicus* have been made and an additional 10 new recovery sites have been documented in 2006. Every year the number of recovery sites increase and this is expected to persist in the future.

Table 2 shows the history of releases of *C. nipponicus* on EHS. The first trial releases were made in 2000.

Table 2. History of Releases of *C. nipponicus* on Elongate Hemlock Scale in NJ

Date of Release	Number	County	Location
4/07/00	5,000	Sussex	Allamuchy State Park
5/03/00	2,500	Hunterdon	Wickecheoke Reserve Upper
6/07/00	2,500	Mercer	Princeton Battlefield State Park
Total	10,000		
6/29/01	3,750	Hunterdon	Wickecheoke Reserve Lower
Total	3,750		
4/18/02	20,000	Sussex	High Point SP, Minisink Valley
5/02/02	15,000	Passaic	Clinton Reservoir, near PSP
5/031/02	5,000	Hunterdon	Natural Lands Trust Preserve
6/7/02	4,000	Sussex	Sparta Mountain WMA
6/7/02	11,000	Warren	White Lake WMA
6/28/02	4,000	Passaic	Wanaque WMA
7/12/02	3,500	Gloucester	Park Lake
8/29/02	1,000	Gloucester	Arlington Blvd and Commodore Dr
9/12/02	1,000	Sussex	Allamuchy State Park
9/26/02	2,500	Passaic	Clinton Road, Site by boat launch
10/10/02	2,000	Passaic	Wanaque WMA
10/25/02	1,800	Sussex	Kittatinny Valley SP
11/7/02	1,500	Hunterdon	Westcott Reserve
Total	72,300		
4/24 - 7/18/03	30,000	Passaic	Clinton Reservoir
9/4/03	4,000	Sussex	Wawayanda State Park
10/15/03	3,000	Sussex	Hamburg Mt. WMA
10/9/03	3,000	Passaic	Dunkers Pond, Newark Watershed
10/14/03	1,500	Sussex	Stokes State Forest, Stoney Lake
Total	41,500		
4/23-5/7/04	50,000	Sussex	High Point SP, Minisink Valley
8/20-9/3/04	5,000	Morris	Kay Environmental Center
Total	55,000		
4/21/05	8,000	Hunterdon	Hackl NJCF property
4/29/05	3,000	Warren	Allamuchy State Park, Stuyvestant Road
4/29/05	3,000	Warren	Jenny Jump SF, Shades of Death Road
4/29/05	2,000	Warren	White Lake WMA, stand 157
5/6/05-7/6/05	6,000	Sussex	Kittatinny Valley SP
5/6/05	2,000	Sussex	Swartwood State Park
5/7/05	2,000	Morris	Rockaway River WMA
5/7/05	2,000	Sussex	Sparta Mt. WMA
5/13/05	4,000	Sussex	Stokes SF near Tillman's Ravine
5/20/05	2,000	Hunterdon	Stanton Station, Hunterdon Co. Parks
5/20/05	2,000	Hunterdon	Pine Hill Section, S.Branch Reservation, Hunterdon Co. Parks
6/3/05	3,000	Sussex	Stokes State Forest
6/10/05	2,000	Sussex	Lake Ocquittunk, Stokes State Forest
6/15/05	1,000	Passaic	Clinton Reservoir, north end
6/24/05	3,000	Warren	White Lake WMA, stand 157
6/28/05	2,000	Sussex	Flatbrook WMA
6/28/05	2,000	Sussex	Walpack WMA
8/4/05	2,000	Sussex	Hamburg Mt WMA, Stand #61
8/4/05	2,000	Sussex	picnic area north of Tillman's ravine, Stokes SF
8/29/05	3,000	Passaic	Echo Lake NWCDC
9/9/05	3,000	Morris	Lake Valhalla PSP

9/23/05	1,500	Warren	Worthington State Forest nr. L. nigrinus site
10/14/05	2,000	Hunterdon	Miller Park Road
10/14/05	2,000	Warren	Jenny Jump SF, Shades of Death Road
10/16/05	2,000	Hunterdon	Creek Road, Stand 138
10/21/05	2,000	Hunterdon	near Ken Lockwood Gorge
10/28/05	2,000	Passaic	Clinton Reservoir, parking lot across from PSP
11/3/05	4,000	Warren	Worthington State Forest nr. PSP
Total	74,500		
4/27/06	10,000	Sussex	Tillman's Ravine near PSP
5/5/06	10,000	Hunterdon	Ken Lockwood Gorge WMA
5/12/ 06	10,000	Warren	Dunnfield Creek Natural Area
5/19/ 06	10,000	Sussex	Kuser Natural Area, High Point State Park
5/26/ 06	6,000	Sussex	Wawayanda Hemlock Ravine Natural Area
5/26/06	6,000	Sussex	Wawayanda Swamp Natural Area
6/2/06-7/20/06	5,000	Passaic	Bearfort Mt. Natural Area, Wawayanda State Park
6/16/06-6/30/06	6,000	Morris	Hacklebarney State Park Hemlock Ravine Natural Area
7/5/06	1,000	Hunterdon	Ringoes, Geil's Tree Service
7/26/06	2,000	Sussex	DWGNRA stand 49.1, Van Campens Brook
9/8/06	1,000	Hunterdon	Miquan Woods County Park
10/12/06	2,000	Pike	DWGNRA Headquarters, PA on community Drive
10/12/06	2,000	Pike	DWGNRA Adams Creek, PA
10/27/06	1,000	Warren	Millbrook Village
10/27/06	1,000	Sussex	Old Mine Road south of Van Campen Inn
10/27/06	1,000	Warren	Van Campen's Glen upper parking lot
Total	74,000		
Grand Total	319,050		

The objective of the project is to establish the beetles in EHS infested hemlock stands throughout New Jersey and the Phillip Alampi Beneficial Insect Laboratory is well on its way to achieving this goal.

Unquestionably, the beetles will feed upon and develop on EHS. There is the potential, then, for *C. nipponicus* to be a biological control agent but it stills remains to be seen whether *C. nipponicus* can be an effective control agent. *C. stigma*, a native coccinellid also feeds on the EHS, but it does not reach population levels sufficient to impact the scale, probably due to the dispersal of the insect as an adult. On beech scale, *Cryptococcus fagisuga*, *C. stigma* fed on the scale in all stages but readily dispersed in the adult stage (Mayer and Allen, 1983). *Chilocorus kuwanae*, an introduced coccinellid, may also have some potential, but Phillip Alampi Beneficial Insect Laboratory personnel have never recovered it from EHS. *C. nipponicus* may be like *C. stigma*, where it feeds on the scale but it may not attain sufficient numbers to control the scale. . Although the beetle is increasing its population in New Jersey forests, the increase is slow and the EHS may not be its preferred host. It will some time before the full impact of the beetle can be demonstrated.

There is another species of *Cybocephalus* in the eastern United States, *Cybocephalus nigrutilus* and it has been recovered from Pennsylvania, Massachusetts, and Rhode Island but there are no records from New Jersey or New York (Smith and Cave 2006). There are some antennal and male genitalia differences but the easiest way to differentiate between the species is to use male characters. The head and prothorax of male *C. nipponicus* are bicolored while male *C. nigrutilus* are completely black (Smith and Cave 2006). None of

the specimens recovered by the Phillip Alampi Beneficial Insect Laboratory were *C. nigrifulus*. Smith and Cave (2006) do not record *C. nigrifulus* as feeding on EHS.

Conclusion

Since 2000, the Phillip Alampi Beneficial Insect Laboratory has been making inundative trial releases of *C. nipponicus* onto *Fiorinia externa*. The beetles have established at 24 sites; five of which have never received releases. *C. nipponicus* is expanding its range and population in the State of New Jersey.

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